The Marine Laboratory
UNIVERSITY OF MIAMI

53-14

FINAL REPORT

Design of a Simple Instrument for Continuous Hydrographic Recording in Tidal Estuaries, Bays and Harbors

October 1953

Office of Naval Research
Contract Nonr 707 (00)

CORAL GABLES, FLORIDA

THE MARINE LABORATORY
University of Miami

53-14

FINAL REPORT

Design of a Simple Instrument for Continuous Hydrographic Recording in Tidal Estuaries, Bays and Harbors

October 1953

Office of Naval Research
Contract Nonr 707(00)

F. G. Walton Smith
Director

Coral Gables
Florida

DESIGN OF A SIMPLE INSTRUMENT FOR CONTINUOUS HYDROGRAPHIC RECORDING IN TIDAL ESTUARIES, BAYS AND HARBORS

SUMMARY

A pilot model recording harbor gage has been produced and tested. It records simultaneously temperature, density, pressure, current direction and current velocity. The unit runs for one week, with two extra days available as a safety margin, taking records every half hour. All measurements except current velocity are well within the accuracy required in harbor surveys. The costs are surveyed and recommendations given for modifications in future models.

OBJECTIVES

A knowledge of hydrographic conditions in bays, harbors and shallow waters and of the flushing mechanism on them has become of primary importance to national defense. The biological problems of such waters, including industrial pollution, as well as the problem of removal of wartime contaminants necessitate the development of recording instruments for measurement of tidal hight, current vectors, temperature and salinity. The Marine Laboratory of the University of Miami has experienced the need for such instruments in surveying polluted estuaries in Florida for state and industrial agencies.

During the past several years, considerable thought has been given by the staff of the Marine Laboratory to the design of such an instrument which could be easily manufactured at low cost and in quantity sufficient to provide synoptic data in the field at small expense of installation and maintenance. Simplicity, portability and dependability were considered the important objectives in designing to achieve the required results.

It is considered of prime importance that all required data be simultaneously recorded only to the degree of accuracy needed for this type of service and that the possible loss of unattended instruments should not be financially serious. The instrument thus serves entirely different functions from more elaborate and accurate instruments of the S.T.D. type.

A proposal that such an instrument should be designed and constructed was submitted to the Office of Naval Research in June, 1951 and approved in December, 1951. First, a preliminary model was to be constructed with no particular emphasis on compactness or similar refinements. This exploratory model is here described with an assessment of its success, and recommendations for modification in future models. Interim reports have already been submitted (52-10, April 1952 and 52-21, December 1952).

The various unit components are described first, then the camera and cycling mechanism, and, finally, the case. Because the model is experimental, more constructional details are given for the individual units than for their mounting, since the latter will undoubtedly be greatly modified in future.

COMPONENTS

Pressure Element. Depth measurement is accomplished by using a bourdon-type pressure gage manufactured by James P. Marsh Corporation of Skokie, Illinois. The gage is modified by substituting a rotating dial for the pointer, and using a fixed index. The rotating dial is of heavy paper, fastened to the original hand and hub. The range is 0 to 30 pounds, with an accuracy of 1%, and the range can be changed by the substitution of another gage. The original gage cost is $2.00. The rotating dial arrangement uses a minimum of the photographic field since only the relevant

portion of the dial, lying behind the index, is included.

The small 45° mirror through which the photograph is taken, is seen in Figure 3.

A closed system containing glycerin transmits pressure to the gage which is mounted inside the top cap of the instrument. A neoprene bulb filled with glycerin, mounted on the outside of the cap at the other end of the system, prevents sea-water from entering the gage. The gage is thus enabled to retain its calibration for a much longer period and prevents sea water from entering the case if the bourdon should rupture. A pressure damper, consisting of two small felt pads and a plug with a #60 hole, is included in the line between the bulb and the gage. This damps out wave action by restricting the flow of glycerin to and from the gage. The gage size and dial arrangement are given in Figure 9.

Temperature Element. Temperature is measured by a bi-metallic, dial-type, testing thermometer, made by Weston Electrical Instrument Corporation, Newark 5, New Jersey, their Model 2261, costing $7.50. This thermometer, with an accuracy of ½ of 1% of the range, is completely encased in stainless steel, except for the scale glass, and has a scale length of 3.40 inches. The drawing in Figure 9 indicates the size and shape of this thermometer.

The range is -40° F. to 160° F., but this same model can be supplied in any range.

The stem of the thermometer extends into a brass well which is sealed into the top cap of the case. Figure 3 indicates the

position of the well in the top cap. This arrangement is used to prevent electrolysis in sea water between the stainless steel thermometer stem and the brass case. Use of the well prolongs the life of the thermometer indefinitely and does not affect its accuracy. Black markings on a white dial make this instrument easy to photograph.

Density Unit. Density is measured by a constant--volume, variable--weight hydrometer designed and built in the laboratory. Variable weight is provided by three fine gold chains suspended from the bottom of the float at 120° intervals from each other. As density increases, the float rises until it supports enough of the chain to restore equilibrium. The chain is #964, 10K gold, made by Speidel Manufacturing Company, and weighs .0625 grams per inch. The outer end of the chains is supported by a lucite ring, as indicated in Figure 8. Use of three chains keeps the float centered in the chamber. The chains are anchored to the float and ring with 24-gage, 10K gold wire clips to simplify replacement of chains and cleaning of float whenever fouling occurs. The float is made of 15 mm. pyrex glass tubing with a volume of 24.2 c.c. giving a calculated rise of .200 inches per 1.00 ‰ salinity change. The inside surface of the float is coated with white lacquer before weighing and sealing. The lacquer provides a better background for the scale which is etched on the outside and filled with marking ink after the rise of the float has been measured in titrated solutions. The scale will cover a change of 20.00 ‰ in 4 inches and can be set to cover any selected range from 0.00 ‰ to 40.00 ‰. The

scale is photographed against a fixed index to eliminate parallax error. A change of 0.20 $^o/oo$ can be read from the float.

The complete hydrometer can be removed from the instrument by removing one screw which clamps it into the 2-inch lucite tube housing. The complete unit is shown in Figure 8 and the installation is shown in Figures 1, 2, and 3. The problem of electrolysis was eliminated by using 10K gold as the only metal in the plastic chamber. The float is photographed through the transparent housing tube by means of a mirror at an angle of 45°.

Current. Current direction and velocity are measured by two vanes pivoted vertically on a common center and spring-loaded against each other. The vanes at rest position form an angle of 120°. A pointer extends from the front of each vane and these lie side by side in the rest position. Both vanes pivot together to indicate direction, and the amount of deflection between the vanes indicates the velocity of the current. The vanes are mounted on the top cap, outside the instrument, directly over the center of a circular lucite window. A paper dial indicating compass points is cemented to the inside of the window, and used to measure the vane direction and deflection. The dial is photographed directly and occupies the main part of the field. Lighting is provided by two bulbs placed adjacent to the dial in position to illuminate the pointers above the window.

This unit has a range of 0 to 2 knots, but has a tendency to change its calibration because of corrosion on the spring and vari-

able friction on the pivot. We intend to replace this unit by a Pitot-type velocity indicator when a new type case is designed.

Compass. A small, uncompensated hand compass, set to one side and viewed by a mirror placed above it provides compass direction. The compass and current dials are oriented in relation to each other and viewed side by side on the film. The compass could be mounted at the center of the current dial with a transparent bottom support. The cost of this compass is $2.00.

Recording Unit. A 16mm., magazine loading, Revere movie camera is used to record data. This camera is modified by moving the shutter mechanism through an angle of 90 degrees permitting timed, single-frame exposures. The camera is triggered by a 6-volt, D.C. solenoid mounted on the side. The solenoid keeps the shutter open as long as the circuit is energized. The exposure time is 1½ seconds at F.16, with Super X film. The magazine holds 50 feet of 16mm film. The lens is a 17-mm, F2.5, wide-angle, adjustable focus Wollensak. The camera is spring wound and will expose 11 feet of film before rewinding. One exposure is made every half-hour over a period of seven days. Camera exposes 8½ feet of film, or 336 exposures in one week, leaving a reserve of approximately two days. The exposed footage is removed in the darkroom and the remainder reconnected to the take-up reel in the magazine. The film requires fine grain development. Figures 1 and 2 show the position of the camera in the instrument.

Camera and lens cost $200, which can be reduced by the use of an 8mm camera or one which uses a smaller magazine.

Optical System. The camera views the instruments either directly or by mirrors. The thermometer and the current dial are viewed directly, while the compass, hydrometer, and pressure gage are viewed by mirrors, as shown in Figure 3. Figure 6 is a highly-enlarged 16-mm frame showing the record taken by the camera. The clock face will be included in any refined model.

Six $2\frac{1}{2}$-volt lamps are connected in series-parallel, as shown in Figure 11. Two are placed adjacent to the current dial, one near the top of the hydrometer tube, one each near the compass, thermometer and pressure gage, as shown in Figure 3. The bulbs are run at a slight over-voltage to increase their emission, and have a life of approximately six months. The upper inside surface of the case is painted white, the top cap is black. The quality of the picture is satisfactory for editing directly from the negative.

Cycling Circuit. The camera and lights are controlled by a small $1\frac{1}{2}$-volt solenoid-drive clock, the heart of the cycling circuit, described in Figure 7. The minute hand carries a sliding silver contact that momentarily closes a 45-volt circuit once every half-hour. The circuit closes a relay with 5000 ohms resistance, charging several capacitors (connected in parallel) simultaneously. The relay closes a 6-volt circuit which controls the lights and the camera solenoid and which will remain closed until the circuit voltage drops from 45 volts to 18 volts. The delay time can be changed by varying the capacitance in the circuit. Four #6 $1\frac{1}{2}$-volt ignition dry cells, connected in series, are used for the circuit which draws 2 amperes. The battery life is sufficient for 2 months' service. A complete wiring circuit is shown in Figure 11.

The clock is imported by El Products Corporation, 501 Madison Avenue, New York 22, New York, and costs $10.00 The dial and contact assembly shown in Figure 7 was made in our laboratory.

The relay costing $3.50 is type LM-5 with a single-pole, double-throw contact arrangement and a 5,000 ohm coil, purchased from Potter and Brumfield, Princeton, Indiana.

This circuit is operating satisfactorily but will be modified slightly to make it more rugged. The battery supply can be reduced to save weight and expense.

Container. Instrument case is made from brass tubing 8" diameter x 1/16" wall x 2 feet long with a brazed flat cap at the lower end, and a 3/4 inch flange at the upper. A stiffening band at the center supports two pivots which ride on a gimbal ring. A brass tripod mount 21 inches high carries the two remaining pivots to complete the gimbal arrangement. The casing is designed to float in a vertical position in the tripod mount. Figures 4 and 10 detail the case and tripod.

The inside of the instrument is suspended from the cap by three ¼ inch brass rods and is removable from the case as a complete unit, as shown in Figures 1 and 2.

The brass top cap fits over the flanged end of the case, and seal is provided by a 1/8 inch thick, flat neoprene gasket compressed by twelve ¼ x 20 brass bolts.

The case is covered on the outside with a liquid neoprene coating, N-200-1, made by Gates Engineering Company, P.O. Box 1711,

Wilmington, Delaware. This coating eliminates the problem of electrolytic corrosion between brazed parts.

DISCUSSION

It must be emphasized that this is an experimental model, designed for flexibility, and that a later model will be simplified and more compact, and cheaper. These aspects are discussed below. The temperature and pressure units are entirely satisfactory. They are easily replaceable, so that alternative units, with different ranges may be substituted as required by the conditions surveyed. The timing and cycling mechanisms also are satisfactory and call for no changes. The density unit is not as rugged as could be wished but stands up well under normally careful handling and can easily be replaced if necessary. Its accuracy is good. An alternative flushing mechanism will be incorporated if the case design is changed in future models.

The compass is satisfactory. The current direction indicator is good, but the velocity is not altogether satisfactory. Further experiments are necessary to see whether a Pitot Tube would be an improvement of the present design.

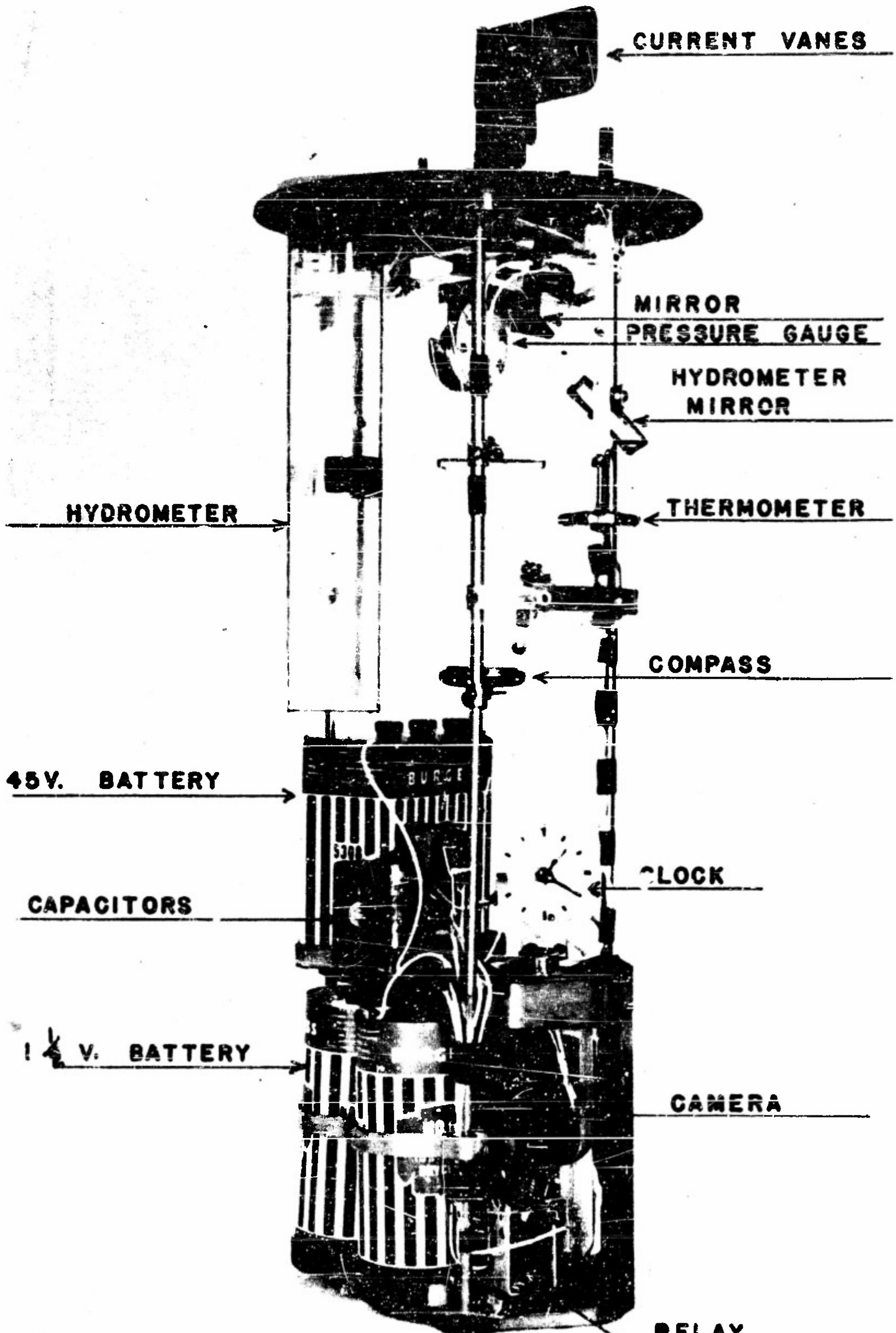
The camera used is unnecessarily expensive and a considerable saving could be effected on this item. Photographic definition is excellent and a saving on the case could probably be made by substituting either a cheaper lens, or 8mm film camera, or both. The optical system is sufficiently flexible to allow ready modification along these lines, or in the case design.

The long axis of the case in a later model should be horizontal to give better stability in a current. The case probably could be made smaller, particularly since battery volume can be reduced. The present batteries provide much more than one week of life and it is a simple matter to replace them each time the unit is serviced.

It is essential that the instrument be relatively inexpensive in order to fulfill its purpose. A number of instruments may be employed simultaneously for a survey and the loss of one or two should not involve a considerable financial loss.

In the pilot model, not including labor, costs are about $200 for the camera, 67 for other parts and raw materials, and $50 for the case. In future models there could be a considerable saving on the camera which is the major expense in the present model. The brass case also could be made more cheaply if the material could be bought in quantity. Costs then would probably not be much over $200 plus labor, the latter, of course, depending on the number of instruments being built at one time.

It is felt, therefore, that the pilot model demonstrates that a reasonably cheap instrument may be produced. Except for current velocity, it meets all the requirements originally specified, and it is fully expected that the difficulties with current recording will be met in future models. Even without velocity records, this is a very useful instrument.



CURRENT VANES
MIRROR
PRESSURE GAUGE
HYDROMETER
MIRROR
HYDROMETER
THERMOMETER
COMPASS
45V. BATTERY
CLOCK
CAPACITORS
V. BATTERY
CAMERA
RELAY

FIGURE 1

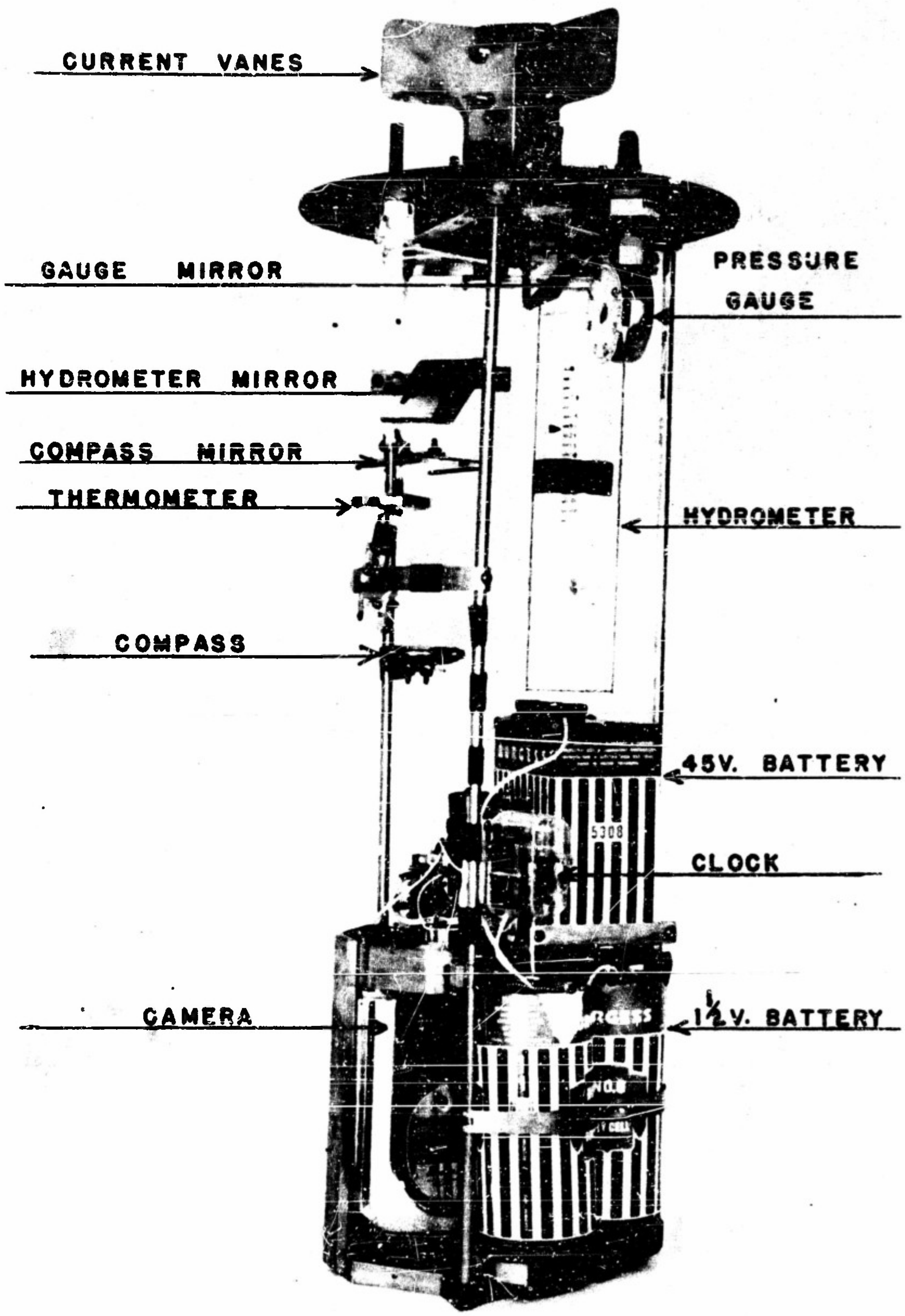

CURRENT VANES
GAUGE MIRROR
PRESSURE GAUGE
HYDROMETER MIRROR
COMPASS MIRROR
THERMOMETER
HYDROMETER
COMPASS
45V. BATTERY
CLOCK
CAMERA
1½V. BATTERY

FIGURE 2

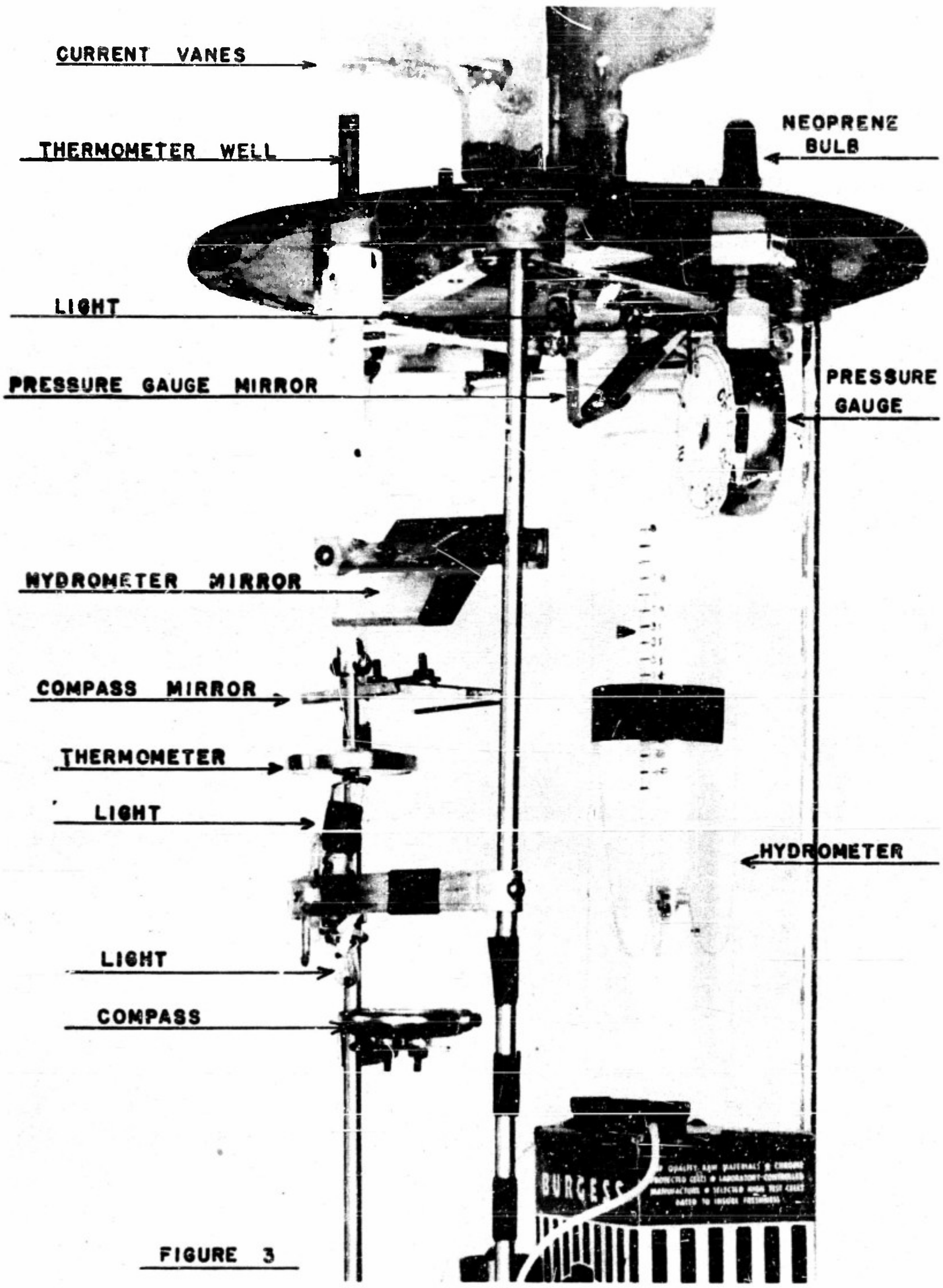

CURRENT VANES
THERMOMETER WELL
NEOPRENE BULB
LIGHT
PRESSURE GAUGE MIRROR
PRESSURE GAUGE
HYDROMETER MIRROR
COMPASS MIRROR
THERMOMETER
LIGHT
HYDROMETER
LIGHT
COMPASS
BURGESS

FIGURE 3

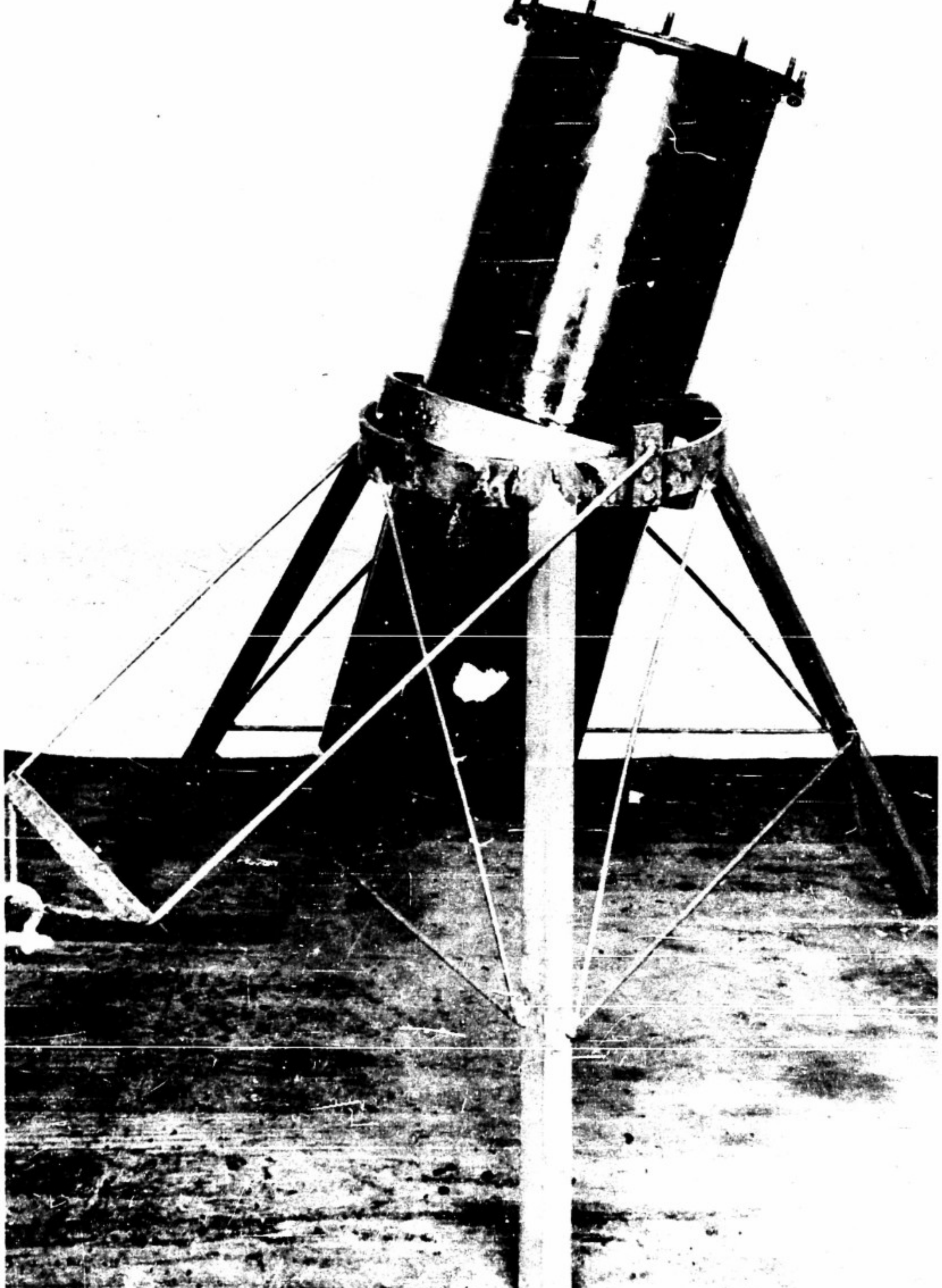


FIGURE 4.

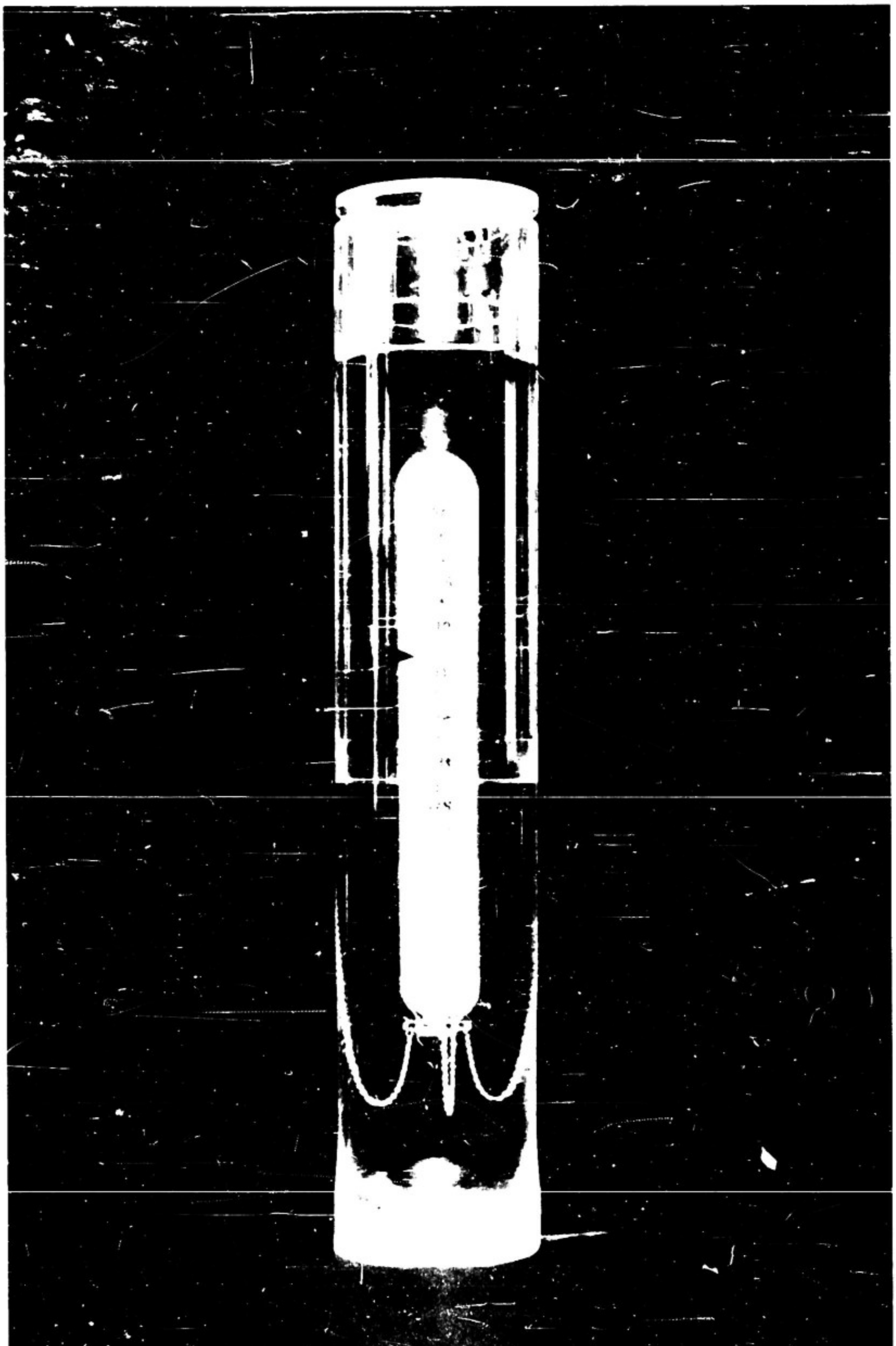
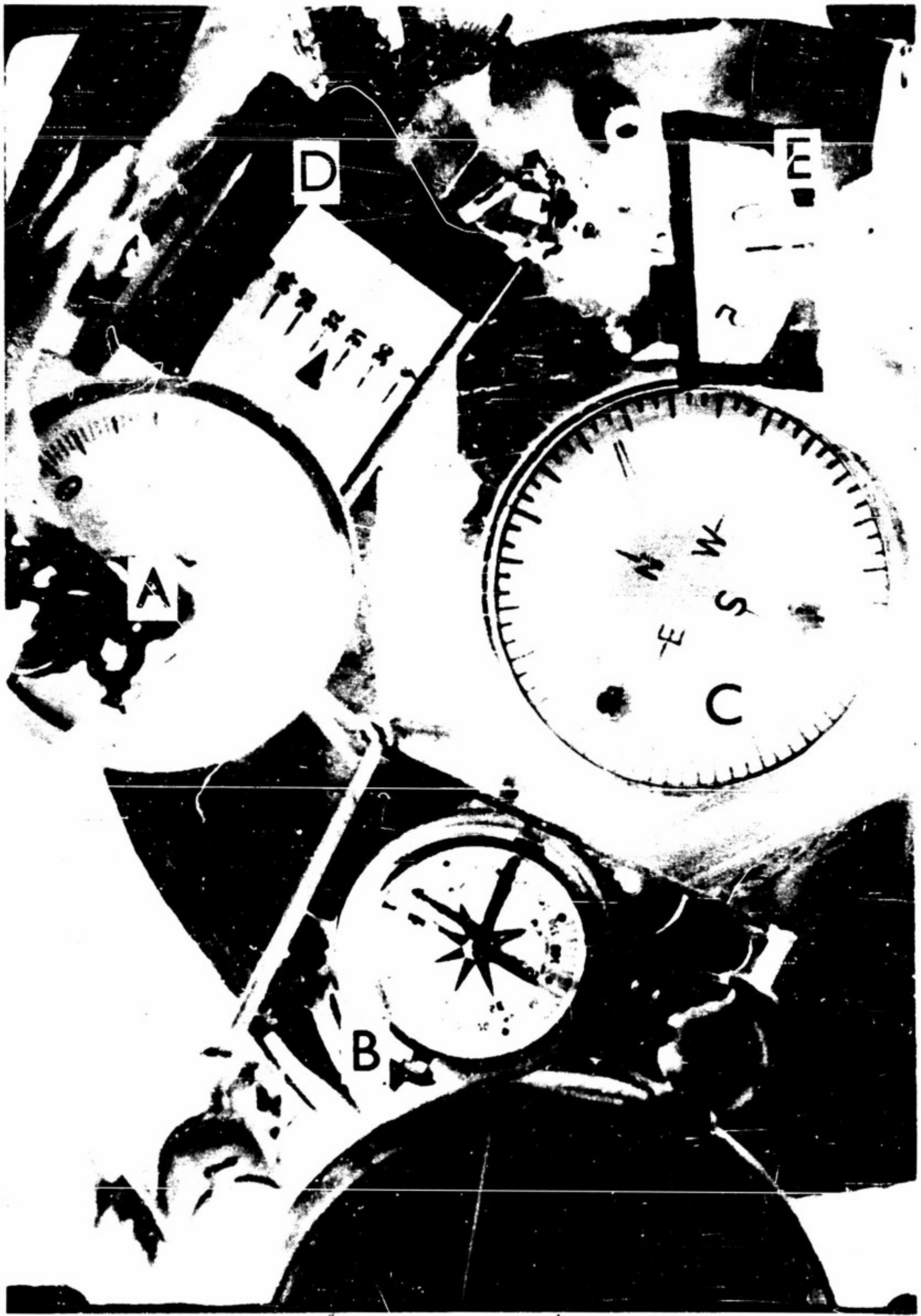


FIGURE 5

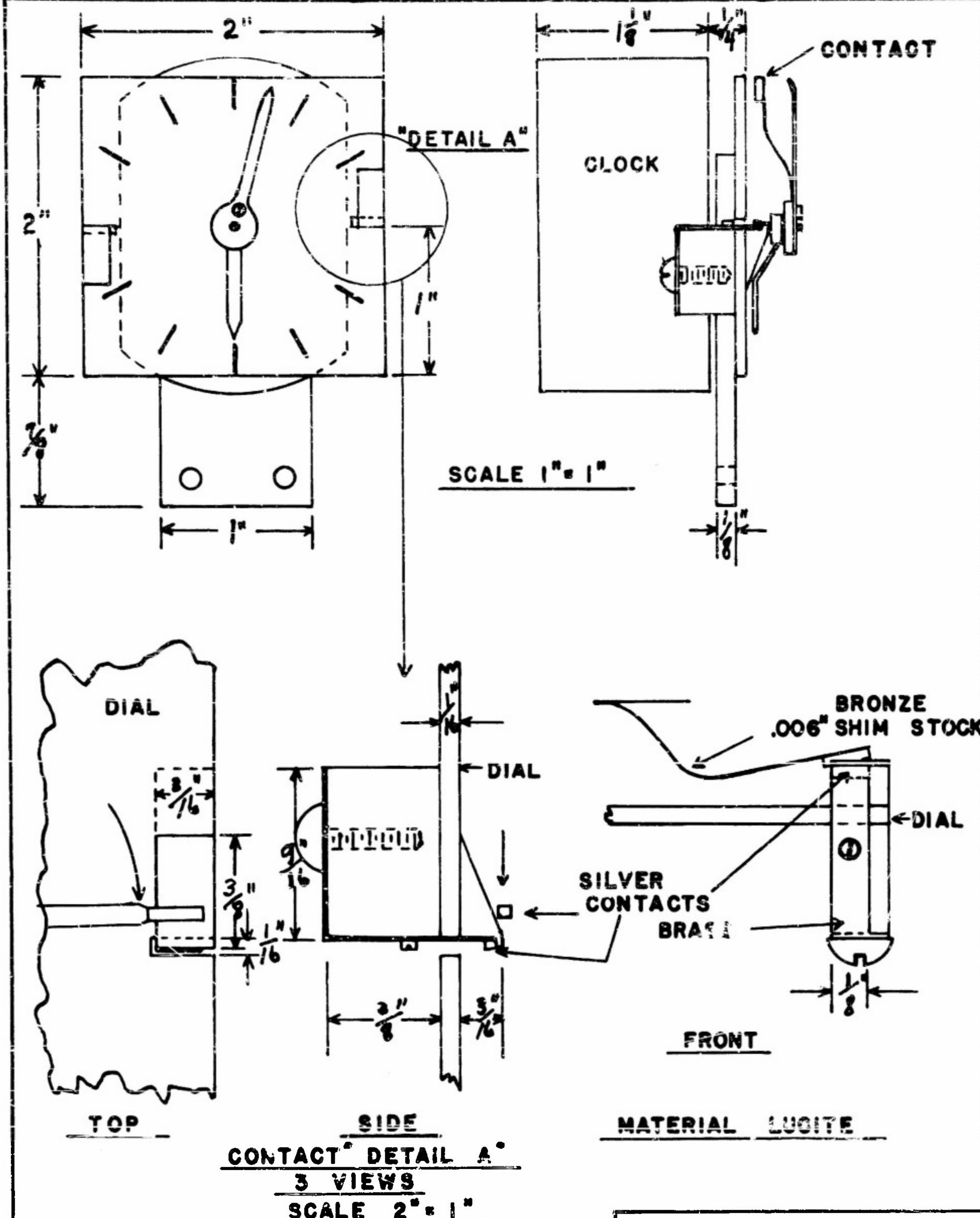


A THERMOMETER
B COMPASS

FIGURE 6

D HYDROMETER
E PRESSURE GAGE

C CURRENT DIAL



CLOCK IS ELIX 365 MADE BY
EL PRODUCTS CORP.
501 MADISON AVE.
NEW YORK 22, N.Y.

FIGURE 7

HYDRO-RECORDER
CYCLING ASSY.
SCALE INDICATED
DWG. J. Potvin
UNIV. OF MIAMI
MARINE LABORATORY

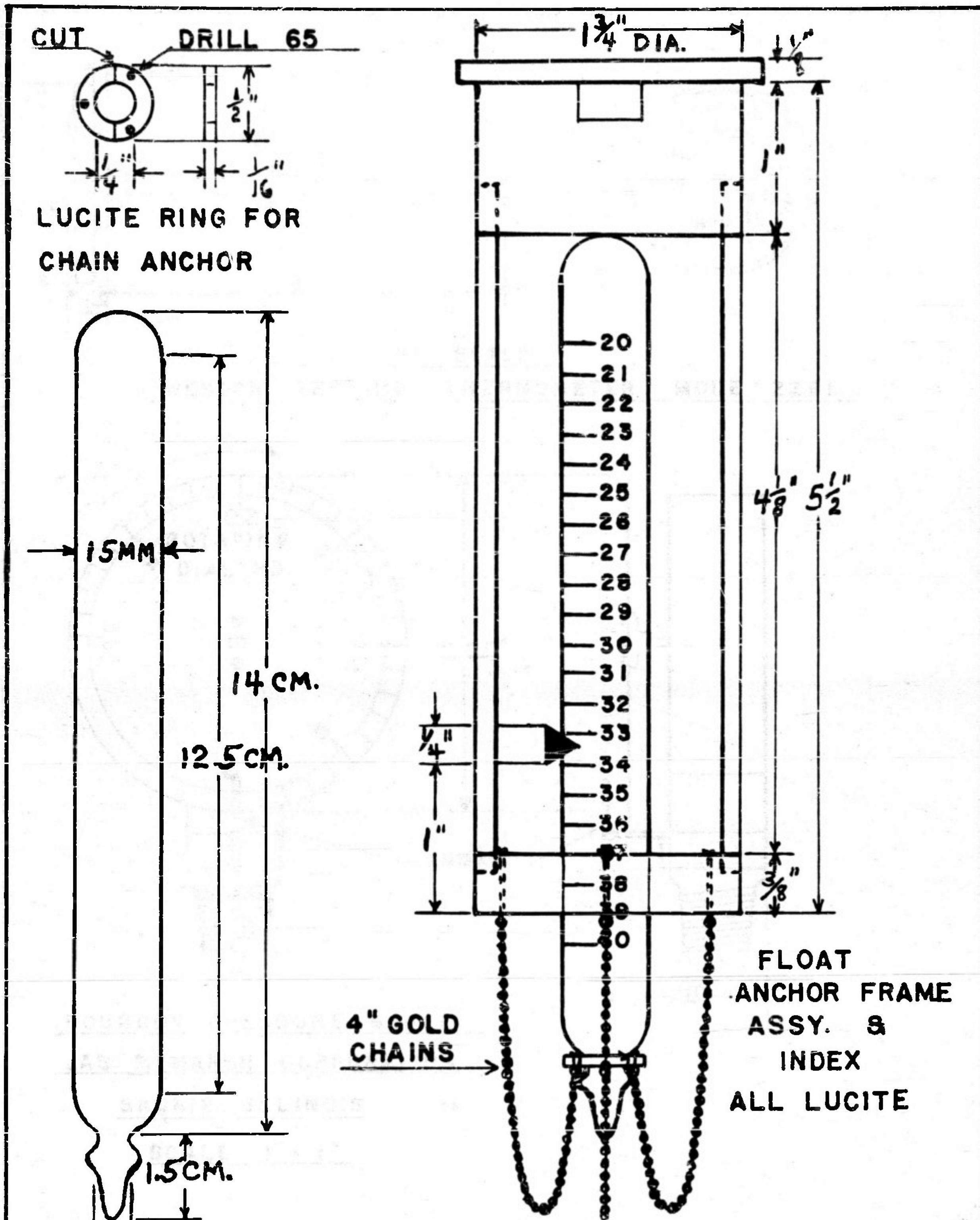
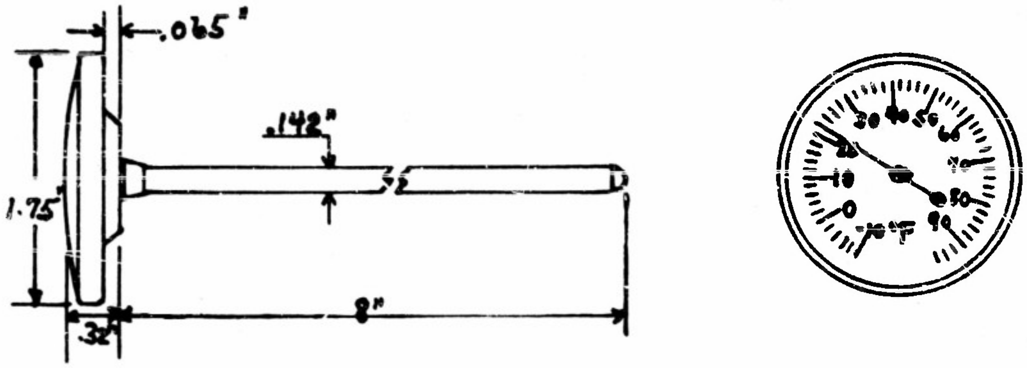


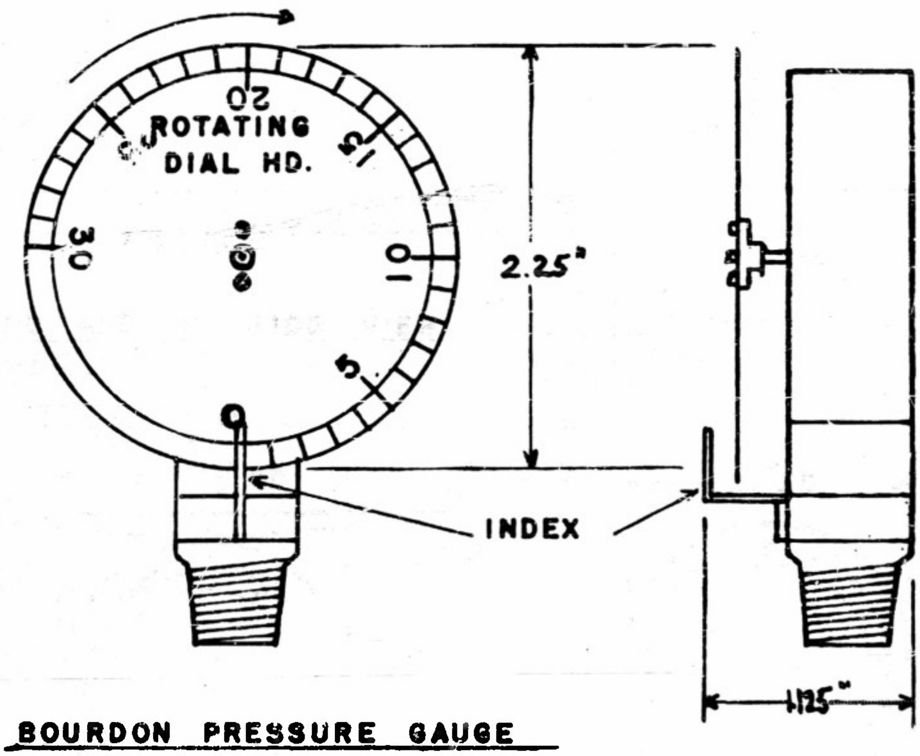
FIGURE 8

HYDRO-RECORDER
HYDROMETER ASSY.
SCALE 1"=1"
DWG. J. Potvin
UNIV. OF MIAMI
MARINE LABORATORY



NO SCALE

WESTON TESTING THERMOMETER MODEL 2261



BOURDON PRESSURE GAUGE

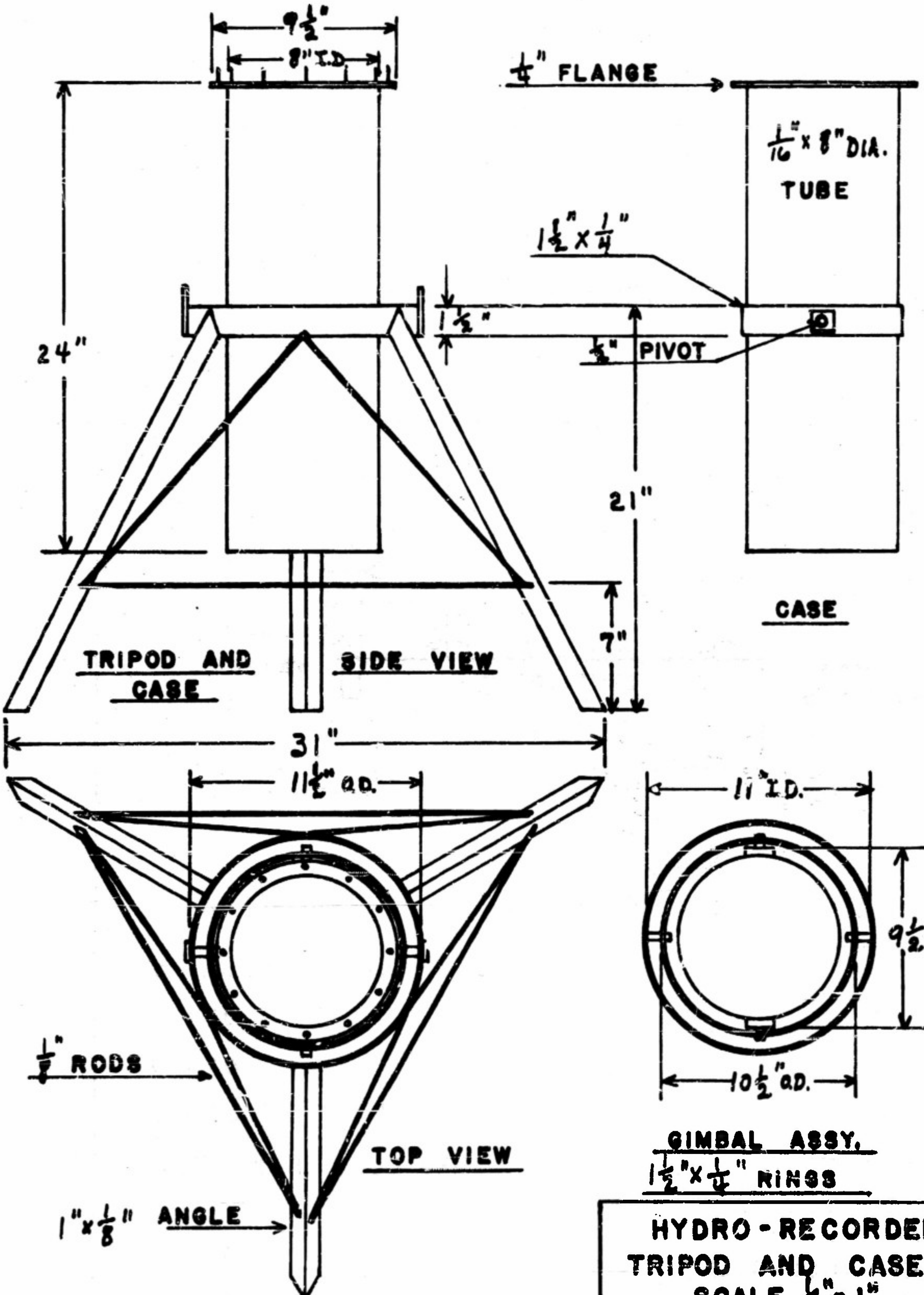
JAS. P. MARSH CORPORATION

SKOKIE, ILLINOIS

SCALE 1" = 1"

FIGURE 9

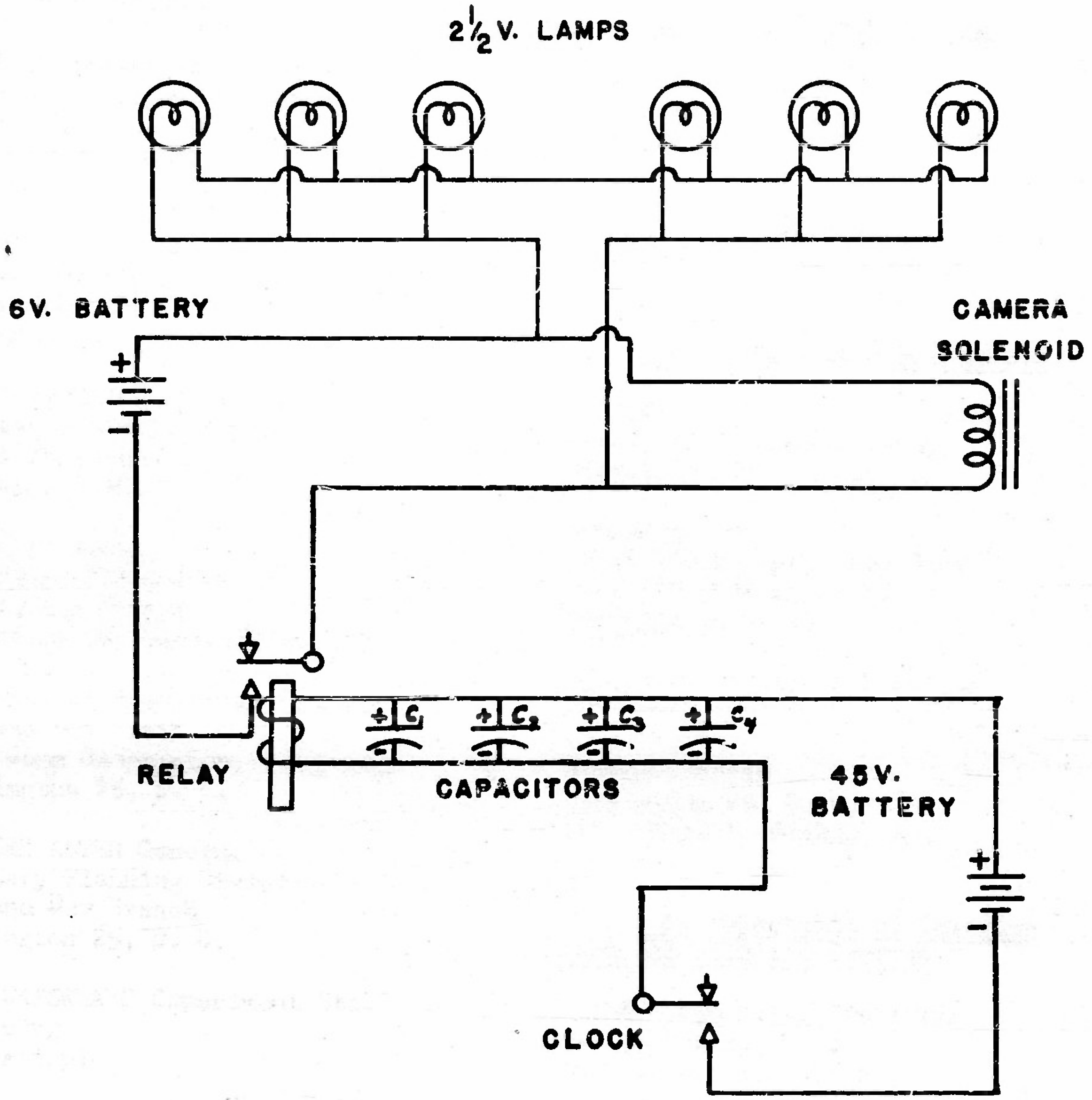
HYDRO-RECORDER
THERMOMETER AND
PRESSURE GAUGE
DWG. J. Patrim
UNIV. OF MIAMI
MARINE LABORATORY



ALL BRASS WITH BRAZED JOINTS

FIGURE 10

HYDRO - RECORDER
TRIPOD AND CASE
SCALE ⅛" = 1"
DWG. J. Potvin
UNIV. OF MIAMI
MARINE LABORATORY



C = 100µfd at 150V.

C = 80 " " "

C = 40 " " "

C = 20 " " "

RELAY COIL 5000 OHMS

HYDRO-RECORDER
CIRCUIT DIAGRAM
NO SCALE
DWG. J. Potvin
UNIV. OF MIAMI
MARINE LABORATORY

FIGURE 11

No. Copies	Miscellaneous
1	Asst. Secretary of Defense for Research and Development Att: Comm. Geophysics and Geog. Pentagon Building Washington 25, D. C.
1	Chief ARMED FORCES Spec. Weapons Proj. P. O. Box 2610 Washington, D. C.
5	ARMED SERVICES Tech Info Cent Documents Service Center Knott Building Dayton 2, Ohio
1	CO, att: CRHSI Cambridge Field Station 230 Albany Street Cambridge 39, Massachusetts
1	NATIONAL Military Establishment Res and Dev Board Att: Comm Geophysics, Geography Washington 25, D. C.
1	QUARTERMASTER General Military Planning Division Res and Dev Branch Washington 25, D. C.
1	U.S. WATERWAYS Experiment Sta. Vicksburg Mississippi
	U.S. Department of Air Force
1	Chief, Air Weather Service Washington, D. C.
1	Dir. for Geophysical Research Cambridge Research Laboratory 230 Albany Street Cambridge 39, Massachusetts
1	Commanding General Research & Development Div. Washington 25, D. C.

No. Copies	U.S. Department of Army
1	Beach Erosion Board 5201 Little Falls Road, N.W. Washington 16, D. C.
1	Commanding General Research and Development Div. Washington 25, D. C.
	U.S. Department of Commerce
1	Director Coast and Geodetic Survey Washington 25, D. C.
1	Commandant Coast Guard, OAO, Room 7132 1300 "E" Street, N. W. Washington, D. C.
1	Office of Technical Services Washington 25, D. C.
1	Weather Bureau Washington 25, D. C. Att: James E. Caskey, Jr.
	U.S. Department of Interior **Fish and Wildlife Service**
2	Chief, Commercial Fisheries Washington 25, D. C. Att: Dr. L. A. Walford
2	Chief, Gulf Fisheries Investi. Fort Crockett Galveston, Texas
1	Chief, Marine Fisheries Washington 25, D. C. Att: Mr. Edwin Dahlgren
1	450-B Jordan Hall, Stanford U. Stanford, California
1	Brunswick, Georgia
1	P.O.B. 3830, Honolulu, T.H.

No. Copies	Academic and Other
1	American Museum of Nat. History Central Park West at 79 Street New York 24, New York
1	Atlantic States Marine Fisheries Commission 22 West First Street Mount Vernon, New York
1	Bingham Oceanographic Found. Yale University New Haven, Connecticut
1	Head, Dep't of Oceanography Brown University Providence, Rhode Island
1	California Academy of Sciences Golden Gate Park San Francisco, California Att: Dr. R. C. Miller
1	Dep't of Engineering University of California Berkeley, California
1	Director, Chesapeake Bay Inst. Box 426A, RFD #2 Annapolis, Maryland
1	Chesapeake Bay Institute Johns Hopkins University 1315 St. Paul Street Baltimore, Maryland
1	Department of Conservation Cornell University Ithaca, New York Att: Dr. J. Ayers
1	Director, Dep't of Oceanography Cornell University Ithaca, New York
1	Oceanographic Institute Florida State University Tallahassee, Florida
1	University of Florida Gainesville, Florida

No. Copies	
1	Director, Gulf Coast Res Lab Ocean Springs, Mississippi
1	Gulf States Marine Fisheries Audubon Building, 931 Canal St. New Orleans 16, Louisiana
1	Allen Hancock Foundation U of Southern California Los Angeles 7, California
1	Director, Hawaii Marine Labs University of Hawaii Honolulu, T. H.
1	Director, Hopkins Marine Station Pacific Grove, California
1	Director, Hudson Labs, ColumbiaU 145 Palisade Street Dobbs Ferry, New York
1	Director, Lamont Geolog. Observ. Torrey Cliff, Palisades, N. Y.
1	Director, Narragansett Mar BioLab University of Rhode Island Kingston, Rhode Island
1	National Research Council 2101 Constitution Avenue Washington 25, D. C. Att: Comm. on Undersea Warfare
1	Dr. Willard J. Pierson, NYU New York, New York
2	Department of Zoology Rutgers University New Brunswick, New Jersey Att: Dr. H. R. Haskins
3	Scripps Institution of Oceanog'y LaJolla, California Director (2) Library (1)
1	Southwest Research Institute 8500 Culebra Road San Antonio 6, Texas

No. Copies	
1	Woods Hole, Massachusetts
1	Fort Crockett Galveston, Texas
1	Washington 25, D. C.

U.S. Department of the Navy

1	Bureau of Aeronautics Project Arowa Naval Air Station, Bldg. R-48 Norfolk 11, Virginia
2	Chief, Bureau of Ships Washington 25, D. C. Att: Code 847
1	Chief, Bureau Yards and Docks Washington 25, D. C.
3	Director, Electronics Laboratory San Diego 52, California Att: Codes 550, 552, 610
10	Hydrographic Office Washington 25, D. C. Att: Hydrographer (1) Division Oceanography (8) Librarian (1)
1	Chief, Naval Operations Washington 25, D. C. Att: Op-533D
1	Commanding Officer Naval Ordnance Laboratory White Oak Silver Spring 19, Maryland
1	Department of Aerology Naval Post Graduate School Monterey, California
2	Asst. Naval Attache Research American Embassy Navy 100 Fleet Post Office, New York
1	CO, Underwater Sound Laboratory New London, Connecticut

No. Copies	
3	Chief, Naval Research Washington 25, D. C. Att: 416, 466
1	Contract Administrator, ONR Southeastern Area c/o George Washington University 2110 "G" Street, N. W. Washington 7, D. C.
3	Director, Earth Sciences Div. ONR, Code 416 Washington 25, D. C.
2	Geophysics Branch ONR, Code 416 Washington 25, D. C.
6	Director, Naval Research Lab. Technical Services Washington 25, D. C. Att: Tech. Information Officer
1	Resident Representative, ONR State Eng'g Experiment Station Georgia Institute of Technology 680 Cherry Street, N. W. Atlanta, Georgia

ONR Branch Offices - CO

1	1030 East Green Street Pasadena 1, California
2	1000 Geary Street San Francisco 9, California
1	John Crerar Library Bldg., 86 East Randolph St., 10th Fl. Chicago, Illinois
1	844 North Rush Street Chicago 11, Illinois
2	OIC, London Branch Office Navy 100, F.P.O. New York, New York
2	150 Causeway Street Boston 10, Massachusetts
1	346 Broadway New York 13, New York
2	Navy Number 100, F.P.O. New York, New York

No. Copies	
1	Department of Oceanography Texas A & M College College Station, Texas
1	Texas Game and Fish Commission Rockport, Texas
1	Head, Dep't of Oceanography University of Washington Seattle 5, Washington
1	Director, Oceanographic Labs. University of Washington Seattle 5, Washington
3	Woods Hole Oceanographic Inst. Woods Hole, Massachusetts Director (2) Mr. W. S. Von Arx (1)
1	Dr. S. R. Galler, Head, Ecology Bio. Branch, Bio. Sci. Div. ONR, Department of the Navy Washington 25, D. C.